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MILITARY

LDP DEFENSE COMMITTEE CHAIRMAN DISCUSSES SEA LANE DEFENSE

Tokyo TOKI NO KADAI in Japanese Jul 83 pp 38-50

[Part-I of Article "Defense of Maritime Nation Japan" by Chairman of National Defense Committee of LDP Motoharu Arima.]

[Text] 1. Advantages of Being Able To Use the Ocean

Economic Aspect and Military Aspect

On 31 April last year, after many complications in the 11th Session of the 3rd UN Law of the Sea Conference, a rough draft of the new Law of the Sea Treaty was adopted, and in December the final signing of the protocol took place. The Law of the Sea Conference was the longest international conference in history, having actually extended over 15 years counting from 1968 when the United Nations Peaceful Use of the Sea Floor Committee was established, which was in charge of the preparations for it. However, the rough draft of this treaty was adopted with a considerable disparity of 130 in favor, 4 opposing and 17 abstaining. As can be understood from the fact that the United States was among the 4 nations casting opposing votes and that 7 West European nations including Great Britain and 8 East European nations including the Soviet Union were among the nations abstaining, it is believed that the new order of the sea to be arranged based on this rough draft of the treaty is still unpredictable.

The reason for this snarl in the birth of a new Law of the Sea Treaty is that there are conflicting advantages and disadvantages regarding use of the sea for each nation, particularly between advanced nations and developing nations, and nothing short of great difficulty is entailed in reconciling these.

To that extent, use of the sea has great benefits for each country, but it can be said that there are two aspects in this use of the sea. In other words, one is traditional sea traffic, or use of the medium of ocean shipping. The other is theuse of sea resources which have come to be of great note with recent advanced developments in science and technology.

It must be noted that these uses have an economic aspect and a military aspect. In other words, there are economic uses such as development of sea floor resources which will become more and more active in the future, along with merchant shipping activities, and potential military uses with the presence of the U.S. and Soviet navies and strategic submarines. The latter have come to be greatly noted along with the rapid increases in the Soviet navy.

Use of the Sea Has Three Special Characteristics

The first special characteristic of the sea viewed from the aspect of uses of the sea is ocean shipping. Regardless of the development of land transport mediums or aircraft, ocean shipping continues to have superior merit over land and air shipping from the aspect of cheap freight charges with capability for large volume shipping.

This is because sea water has more bouyancy than air and the friction resistance of traveling on the sea is less than traveling on land. According to one explanation, it has been calculated that the weight which can be moved by 1 hp of energy is about 15 pounds for aircraft flying in the air, 100-200 pounds by a vehicle traveling on a road, 600-1,500 pounds by a vehicle traveling on a track, and 2,000-9,000 pounds by a ship traveling on the sea. A rough estimation of sea, land, and air shipping expenses it 1:5:50, and clearly ocean shipping has the advantage.

The second special characteristic of the sea is its worodwide expanse. The total sea area of the world is about 370 million square kilometers and it occupies about 71 percent of the surface area of the globe. However, there are not national borders at sea as there are on land and direct connections with neighboring countries are via public seas. As it is said, "The water of the River Thames is conveyed throughout the world."

The Third special characteristic is the bountiful resources possessed by the ocean. Of course, marine product resources in the ocean have been used for a long time, and a variety of resources exist such as matter contained in seawater and mineral resources on the sea floor. As these resources have become easier to use along with advances in science and technology, the special characteristics of the sea in these aspects have come to be spotlighted.

The Sea Has New Value

Formerly, at the beginning of the 19th century, Captain Alfred T. Mahan, an instructor of strategy at the U.S. Naval Staff College, published a treatise on sea strategy, based on historical examination, concerning the use of the sea for development of a maritime nation and the ideal guarantee of its safety. This work had many contributions in opening the eyes of the United States as a maritime nation.

This treatise exerts a large influence even today on sea strategy theories of the world. The use of the sea stated in it is sea traffic, or in other words, ship navigation. Even today, that importance has not changed in the slightest. Advanced free nations which are maritime nations have been able to obtain great profits by using marine transportation for theimport of raw materials and the export of manufactured goods, and they have become prosperous as modern industrial nations. The existence of major industrial belts in coastal zones or along waterways not only in Japan, but in the advanced nations of the United States and Europe indicate that great profits have been obtained using merchant shipping for the transport of raw materials and manufactured goods.

The sea traffic probably will play a more and more important role in the existence of mankind and the development of culture in the future is clear from the fact that the ocean shipping volume for worldwide trade was about 2.699 billion tons in 1971, and has constantly increased to about 3.463 billion tons ten years later in 1981.

It is hardly necessary to mention the importance of marine product resources such as fishery products and types of seaweed. Particularly for Japan, ocean life resources are a major supply source for animal protein and viewed over the entire world, considering the trend toward increases in the population and amount of intake of animal protein in developing nations in the future, the importance of marine products is certain to increase more and more.

However, along with the recent advances in science and technology, multiple and diverse uses of the sea are flourishing in addition to the traditional uses of the sea such as sea traffic and fishing. Accompanying this, various international problems also have arisen.

Economically, a problem has arisen in the competition between foreign countries along with large volume catches through improved fishing methods and expansion of sea areas for fishing. In this connection, the total catch of fishing boats in the world was 16 million tons in 1950 and greatly increased to 72 million tons in 1980. According to 1981 statistics, sea floor oil production was 700 million tons or about 25 percent of total production worldwide, but since technical development of very deep sea floor oil exploitation is rapidly being realized, the view is that this ratio is certain to increase more and more.

Manganese nodules are promising as a mineral resource of the ocean floor. According to a former extimate of the U.S. Department of Defense, by use of manganese nodules existing on the deep ocean floor, the world consumption of copper can be supplied for 1,100 years, nickel for 23,500 years, manganese for 34,800 years, and cobalt for 260,000 years.

The ocean also is important as an energy source to replace oil. If the nuclear fusion industry which, it is said, will solve the energy problems of mankind in one stroke is realized, the deuterium in seawater has long been known to be an unlimited resource. In addition, as is commonly known, there has been progress in realization of extracting uranium from seawater and generation of electricity by suing tides and waves.

Sea Gives Secrecy To War Power

Next, in viewing use of the sea from a military aspect, first of all, as indicated by history, the sea has been a large obstacle to invasion, particularly an invasion attack by ground troops. To invade by sea, a military force superior to the ground troops of the opponent's country must be sent in, prepared for sacrifices at sea. Perhaps it is well to remember the landing operations at Normandy, but massive military power and a method to transport it by sea must be secured for a landing invasion via the sea.

Next, in a reverse relationship to this, the ocean is convenient for sea traffic with its worldwide expanse and since large volumes can be shipped, it is possible to provide a presence in peacetime and an introduction of war power from sea to land in an emergency. In particular, a great reason for the Soviet Union coming to build a mighty ocean-going navy is said to be attention to the effect of its presence, or in other words, old fashioned "gunboat diplomacy". This will be discussed in more detail later.

In the Falklands conflict also, the British Navy introduced a landing force with the dispatch of a fleet 8,000 miles away, and the introduction of a war force from sea to land to recapture the islands was an important use of naval power, making the most of the special characteristics of the sea.

In addition, it cannot be forgotten that the ocean can make a large contribution to the survival of war power. Particularly, the sea provides a thick viel for submarines and maintains their secrecy. The methods of detecting a submerged submarine for the present must chiefly be devices inevitably using echoes and magnetism. Since the performance of both of these are influenced by the properties of the sea, great effort is required to detect a submarine in anti-submarine warfare.

Added to this, there has been a gradual increase in the operational capability and undetectability of submarines along with the general use of atomic powered propulsion engines. Furthermore, SSBN have come to occupy a position as the most important vehicle of strategic nuclear power through the strengthening of equipment and functions such as underwater launched missiles, high-efficiency underwater navigation and deep submergability.

The "Ohio," the first supersize SSBN of the U.S. Navy that was recently commissioned, has an underwater displacement of 18,700 tons, and the TRIDENT 1 missiles to be carried aboard in the future are said to have a range of about 4,350 miles. According to this, even if launched from underwater near the coast of the United States, they would be able to enter the range of the Soviet mainland.

To oppose this, the Soviets has the TYPHOON class SSBN which is presently under construction, and the range of the SS-NX-20 missiles onboard are said to have a range of about 4,500 miles.

2. Japan Is A Typical Maritime Nation

Export/Import Volume of Japan Is 19 Percent of World

A maritime nation possesses the geographical conditions enabling use of the sea, and it can become a nation which greatly depends upon this for its existence and prosperity.

Japan is an island country surrounded by seas on four sides. The total land area is about 370,000 square kilometers and it is 55th in area in the world, but the 200 mile territorial economic zone has an area 10 times that of the land, making it 7th in the world following the United States (1.97 times that of Japan), Australia (1.81 times), Indonesia (1.4 times), New Zealand (1.25 times), Canada (1.22 times) and the Soviet Union (1.16 times).

Furthermore, although Japan is among the advanced nations, it is a country particularly poor in resources and has largely depended on imports from abroad for raw materials for industry, including energy, of course, and even for food-stuffs today. The transport of these is almost all by ship and its maritime transportation routes extend to the oceans throughout the world.

In this connection, according to UN statistics, about 19 percent of the total ocean shipping volume worldwide in 1981 was the volume of Japanese exports/imports (imports about 570 million tons, exports about 80 million tons). Also, Japanese shipping (steel ships over 100 gross ton) totaled 10,422 ships according to Lloyd's Register of Shipping, greatly out-distancing Liberia in 2d place with 2,281 ships. In gross tonnage also, it was in 3d place (40.836 million gross tons) following Liberia and Greece.

Japan is blessed with favorable geographical conditions for the utilization of the sea, and its existence and prosperity depend entirely on the utilization of the sea. Moreover, it is believed that the value of the sea will continue to increase in the future.

Forgetting That It Is An Island Country

Regardless of the fact that Japan is a typical maritime nation, an unexpectedly small number of people perceive this. It is believed that this results from the fact that unlike the European Powers who formerly o-er several centuries rode across distant oceans in a cavalcade of large sailing ships, advanced into the continents of Asia and America, and achieved national development, Japan at precisely the same period had conversely promulgated austere isolationist laws and confined itself to an island nation. For this reason, the people precluded the opportunity to cultivate an "ocean mind" via historical experience.

There is a sense that the recent much talked about question of "defense of the sea lanes" is belated for an ocean nation. There have been public declarations from the beginning that there can be no defense and the center of debate on the whole has been far from the essential argument, such as whether 1,000 nautical miles is too far on whether a sea lane is an area or a line.

The perception of the military has been extremely shallow due to the fact that open debate about the military has been viewed as taboo in Japan since the war, but it is believed that more than anything, there is a lack of adequate understanding about the ocean. The problem is that Japan forgets it is a small island country in a vast sea which occupies 70 percent of the globe and can only be viewed on a map to the scale of 1/50,000.

Regardless of such lack of national perception, it is a fact that Japan up until now has come to depend greatly on the use of the sea for the existence and prosperity of the nation, and the degree inevitably will increase more and more in the future. Furthermore, the military threat against free use of the ocean has greatly increased today. The essence of the question of "sea lane defense" must truly be perception of that fact.

3. West Defends Strategy of Ocean Nation Groups

Degree of Dependence on the Sea Is Large for the West

International relations have a tendency to be multipolar in aspects such as politics, economic and culture, along with deepening mutual dependence. The world military structure, however, is based on the opposition of the Eastern and Western camps with the respective nucleus of the Soviet Union and the United States, which have overwhelmingly strong military power in strategic nuclear war capability and conventional war capability, and it appears that this will not change in the foreseeable future.

Within this, Japan is united in an ally relationship with the United States, and the U.S.-Japanese security structure forms the basic framework of national defense. Also, having a liberal democratic structure as national policy, the basic route for Japan in politics and economics has been strengthening the maintenance of common bonds with free nations, including the United States, and it can be said that this is the general consensus of the people.

This is clear when viewed from the fact that the present economic prosperity of Japan centers on bonds with the United States and largely depends on being able to enjoy a free economy in the world, and furthermore, over 90 percent of the people today have a middle class consciousness. In other words, Japan is a member of the Western camp in both name and fact, and selection of this basic route is appropriate for the national prosperity of Japan.

However, there are antithetical differences in the respective basic strategies within the military structure of East-West opposition in accordance with the geopolitical conditions of each camp. The Western camp, that is the United States and its allies or free nations with which it has friendly relations, are almost all maritime nations. They are positioned with the oceans separating them. In this connection, there are 45 nations which are tied in an ally relationship with the United States. Among these, 42 are maritime nations and a scant 3, Luxembourg, Bolivia, and Paraguay, are countries which do not face the ocean.

Consequently, for the Western nations, maintenance of free and safe use of the sea is a common benefit which is indispensable for the existence and prosperity of the country, and Western nations preserve these mutual bonds by sea traffic.

On the other hand, the Eastern camp, which has the Warsaw system centering on the Soviet Union as its base, unlike the West, is composed of a group of continental nations. Since they either cannot obtain use of the sea, or their military and economic bonds within the bloc are tied by land transportation routes, the use of the sea is not a vital requisite for the existence and prosperity of the nation. For example, as opposed to the ship tonnage of the West which occupies about 60 percent of the world's total, that of the Eastern camp constitutes no more than 10 percent of the total. (1981 gross tonnage according to statistics of Lloyd's Register of Shipping)

Offensive Strategy of the East

From these facts, within East-West opposition, the Eastern camp can establish superiority by possessing a military posture which can deny the Western camp the vital use of the sea. As opposed to this, the Western camp can obtain a balance by constructing a defense posture which can protect the use of the sea from obstruction by the East and maintain safe use. In other words, as opposed to the Eastern strategy which normally is offensive, the West has taken a defensive stand to withstand an attack by the East.

For example, if the Warsaw camp should invade Europe, the NATO camp would need to bring in reinforcements and military supplies promptly and continuously from the North American continent. Although troop transport on such an occasion would be by air transport, heavy weapons and ammunition, etc., which occupy the other greater portion of weight would be by sea transport. The mission of the Soviet Navy is to intercept this sea traffic in the North Atlantic Ocean and cut off support from the United States. By this means, the Warsaw camp can gain an advantage on the European war front.

On the other hand, the navies of the NATO countries, including the United States, have the mission of defending such sea traffic and by this means, can strive to maintain continuous fighting capability. Of course, this

offense and defense concerning sea traffic is not limited to these military items, but also is targeted against economic goods, in other words, the ocean transport of import commodities from aborad which are indispensable for the existence of the NATO countries of Western Europe.

In this way, the East-West balance of military power in Western Europe means a balance of East/West military posture concerning offense and defense of sea traffic which is vital to the West for basic maintenance of continued fighting and existence. In other words, the NATO camp can strive to deter first invasion by maintaining a defense posture which can deal with an attack by the Soviet navy.

The defense of Japan, based on the U.S.-Japanese security structure, is the same as this. The maintenance of a posture which can effectively defend Japanese sea traffic against an attack by the Soviet Union will deter invasion. Defensive strategy, which is the strategy of the West, has become the base of Japanese national defense strategy.

4. Buildup of Soviet Naval Power Indicates Offensive Strategy of East

Soviet Navy Resolved To Switch Strategy

In recent years, it has been clear that buildup of the Soviet military has emphasized naval power along with nuclear power. This reflects an offensive strategy as the base in which a superiority can be established in the East/West opposition relationship by the Soviet Union building a posture which can deny the Western camp use of the sea.

Today, the Soviet navy has grown from its traditional major duty of coastal defense to an ocean-going navy which has power even rivaling the United States, and furthermore, the buildup is steadily increasing. The first step was in the1950's when East/West opposition became serious.

In particular, the Soviet navy formerly possessed a large fleet in the Imperial Russian era, but being primarily a continental nation, it was not used to expand and develop national power like the fleets of maritime nations. It was employed solely to support ground combat, and adding the overwhelming defeat it received in the Battle of the Japan Sea, even in World War II, hardly any action at all was to be seen. When the Second World War broke out in Europe in 1939, however, the Soviet Union had 165 submarines as opposed to the 35 submarines of Germany and 95 submarines of the United States. It is very interesting that when the Soviet Union entered the war in June 1941, it possessed the largest scale fleet in the world at the time, with 218 submarines. In this connection, Japan had 65 submarines at the time.

After World War II, the Soviet Union acutely felt the need to build a great navy, having undergone the painful experience, due to itself possessing only a weak naval power, of not being able to lend a hand against the actions of the U.S., British and French navies in the Greek Civil War (1955),

Suez disturbance (1956) and Lebanon clnflict (1958). Particularly in 1962, as is known, the incident in which they were forced to withdraw strategic weapons from Cuba due to the decisive action by President Kennedy of a naval blockade by U.S. naval units, made Soviet government leaders decisively resolve to switch from the previous coastal navy to a so-called blue water navy.

The Four Objectives of the Soviet Navy

Even from the 1960's to the 1970's, when U.S. national defense efforts did not go as expected due to the influence of a trend toward detente which was symbolized by a series of treaties related to armament control such as SALT and the Helsinki declaration, and additionally the Vietnam War and its aftermath, its efforts to form such an ocean-going naval power were not interrupted and it has continued consistently until the present day. It is said that by the accumulative effects of this, it has now come to surpass the U.S. Navy in some aspects.

From the viewpoint of the offensive strategy of the East, it is necessary to note the following points in particular concerning the recent power of the Soviet navy and its actions to surmise the intentions and capability of the Soviet Union:

First of all, the duties of the Soviet navy are clearly stated. Fleet Admiral Gorshkov, Admiral of the Fleet of the Soviet Union, has stated the duties of the Soviet Navy in the "Soviet Military Encyclopedia". According to this, "interruption of enemy sea traffic" is clearly cited in addition to strategic nuclear power, cited as a duty of the U.S. Navy, sea control (guaranteeing use of the sea by allies at the necessary time and place--protection of sea traffic, for example, is included in this), and power projection (introduction of military power from sea to land--landing operations, etc.), and similar items.

Secondly, it possesses an unusually large number of submarines, which are most appropriate for interruption of the sea traffic of the West. According to the newest edition of Jane's Fighting Ships of the World (1982-83), the number of submarines possessed by the Soviet Union is as per Table 1. It is overwhelmingly great compared to the U.S. Navy. Moreover, effort is being put into equipment of atomic powered submarines which are superior in scope of action, attack capability and maintenance of the secrecy that is the life of the submarine.

Thirdly, there has been a buildup of bombers capable of long-range warfare such as the BACKFIRE, and the intention is to destroy the anti-submarine warfare capability of the enemy, acting in concert with submarine warfare. In his article "A Navy In Wartime And Peacetime", Fleet Admiral Gorshkov stresses that from the war lessons of World War II, there is a necessity for further increasing the results of submarine warfare interdicting sea traffic by uniting aircraft with submarine warfare.

Table 1.

Number of submarines possessed by Soviet Union & United States		Soviet Union Total	Soviet Union Pacific	United States Total	United States Pacific
Strategic Attack	SSBN	69	24	34	0
	SSB	16	7	0	0
Nuclear Submarines	SSGN	49	20	0	0
	SSN	58	19	92	41
	(Subtotal)	(107)	(39)	(92)	(41)
Conventional Class	SSG	30	4	0	0
	SS	155	47	7	7
	(Subtotal)	(175)	(51)	(7)	(7)
Total number of submarines		367	121	133	48

<u>Jane's Fighting Ships</u> (1982-1983)

The safety of the submarines is heightened by high performance bombers fighting the anti-submarine power of the enemy in concert with submarine warfare, and it is believed to give a further advantage in attacks against ships. The possession of high performance bombers presupposes a communications and reconnaissance network covering a wide area with the use of satellites. The former is the BACKFIRE, and it can be easily surmised that the latter already has considerable capability.

The BACKFIRE has an operational radius of over 3,000 nautical miles, if aerial refueling is conducted, and from the coastal states and Petropavlovsk Base, the entire area of the northwest Pacific Ocean can easily be put within its sphere of operation. It is a high performance bomber which flies at over Mach 2, and in addition, carries anti-submarine missiles (AS-4) with a range of over 300 kilometers. The Soviet Union possesses over 150 of these aircraft in all. Over 50 of them are stationed in the Far East, and it is said there will be a further buildup in the future.

Fourthly, the Soviet Union is making an effort to improve its weak points in employment of naval power by the presence of naval power, or by acquisition and equipping of overseas bases. Along with a buildup in its ocean-going naval power, the Soviet Union has been gradually enhancing its naval presence with its ships since the 1960's with deployment to the Mediterranean Sea, Indian Ocean, Pacific Ocean, and the Caribbean Sea.

Sea Area Surrounding Japan Is Heightened Threat

The significance of the presence is by quickly deploying ships in the vicinity to the coastal waters of an area of conflict should a conflict arise such as in a third world area, and to establish clearly the will and actual power of the Soviet government to support left wing revolutionary forces by displaying the Soviet flag and its mighty armed force un-er one's nose. As a result, in most cases, revolutionary forces which are evenly matched with government forces will be decidedly encouraged and it will lead to the success of the revolution in one stroke.

Since the United States believed in detente and overlooked this presence of the Soviet navy in the 1970's, the Soviet Union was able to devise a great expansion of its influence in the Indian Ocean area, which the British Navy had vacated. In such an area, the Soviet Union was able to expand its facilities so that they could be used as naval bases. As a result, the Soviet Navy has greatly improved its weak point geographically in being restricted in advancing into the ocean through straits under the control of the West.

It is clear that the Soviet Union intends to repeat activities planned to further expand its influence by turning its presence to further advantage with a foothold in newly acquired bases. The "U.S. Defense Report (Fy 1984)" submitted by Defense Secretary Weinberger to the U.S. Congress last 1 February stated the following in this connection. "The geographical expansion of Soviet influence has important military significance. Today, the base facilities which Soviet naval ships and aircraft can use in Cuba, Vietnam, South Yemen, Angola and other areas have increased the supreme capability of the Soviet navy in fighting any war at sea."

It is said that the greatest reason for pouring effort into the acquisition of surface ships such as the Kirov Class cruiser, which seems extra-ordinarily strong from outward appearance, is for the purpose of this presence.

Thus, the Soviet Union is steadily preparing a posture which will enable further expansion of military attacks against the sea taaffic of the West.

To sum it up, today the Soviet Union possesses great naval power, and it has the capability of being able to wage war in oceans throughout the world. It is making the most of peacetime as a method to accomplish its policies to expand naval power. As a result, it has strengthened its offensive military posture at sea to enable it to deny the Western camp use of the sea, and maintains itself in a superior position in the East/West military balance. Today, the Soviet Union already has the capability to attack sea traffic, which is the lifeline of the Western nations, in the oceans throughout the whole world, and it is trying to further increase that capability. Concepts based on this offensive strategy of the East have aggravated the East/West opposition and has made it inevitable for the West, which has taken a defensive standpoint, to strengthen its defense posture to cope with it.

Particularly in viewing the sea area surrounding Japan, the Soviet Pacific Fleet possesses about 1/3 the strength of the whole Soviet navy, and it has been steadily augmented among with the other fleets. The rate of increase for tonnage greatly exceeds the rate of increase for ships. It has increased about 50 percent from about 1.05 million tons 10 years ago to 1.6 million tons in 1981 (rate of increase for ships was 12.5 percent), and this indicates a trend toward enlarging the size of ships. The Soviet Pacific Fleet today has a strength of about 810 ships and about 1.6 million tons, and this is the largest share among the 4 Soviet fleets.

Furthermore, as was reported in a newspaper in October last year, it appears that the expansion of Soviet naval bases in the Northwest Pacific Ocean area is being hastened further, such as with the ship base on Simushir Island in the Kurile Archipelago, Alekseyevskaya Air Base in the coastal states, or the Camranh Bay Base in Vietnam. By the expansion of these bases, the threat to sea traffic in the sea area surrounding Japan has been further heightened. (Subtitles in this article have been added by the editorial department) (To be continued)

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FUJITSU'S PRECISION ASSEMBLY ROBOT FAROT-M6 DESCRIBED

Tokyo FUJITSU in Japanese Apr 83 pp 547-555

[Article by Kazuo Tamamushi, Takashi Uchiyama, and Toshifumi Mashima, Kawasaki Laboratory, Fujitsu: "Robot for Precision Assembly"]

[Text] 1. Introduction

The industrial robot was developed about 25 years ago in the United States and was introduced to Japan about 15 years ago. At the initial stages of development, the robots were of low performance and could not be used in special areas. Since then, after about 10 years of research and development, robot performance has been increased until it has been introduced into body assembly in the Japanese automobile industry as a welding use machine and its position as production equipment was established. The area of application has undergone wide expansion recently, and development of technology to use robots to perform assembly operations which have depended on human effort has become very active. The development of robots operating at high speed and precision compared to the past as well as with intelligent capabilities is necessary in order to utilize them for assembly operations. As developmental research along these lines advances, robots which even perform special office functions may be developed.

Fujitsu has been promoting robot development mainly for in-plant use, and the assembly robot FAROT-M6 (Fujitsu Automatic Robot-M6) which will be introduced in this paper was developed recently.

2. Background and Purpose of Development

It is only recently that automated assembly has become a major subject. Product processing has seen great advances in automation, with the general use machinery of the past being replaced by special use machinery. In contrast, assembly processes have relied on human hands right up to the present, and automation and conservation of labor are looming as major subjects. In surveys conducted on distribution of labor in the production processes of automobile parts manufacturers, it was reported that about 55 percent of total labor was taken up by assembly processes [1]. The same trends exist in the electrical industry and the precision machinery industry where the distribution of labor to assembly processes is even higher. In addition, these industries lack assembly technicians, and there are major moves toward utilization of robots for assembly purposes. Furthermore, the recent developments

in the electronics area centered on microcomputers have resulted in improved performance and operability of robots, and the economic aspects of robot use have resulted in sudden increase in its greater use. It is believed that the assembly robot plays a central role in present developments.

It was possbile to recover investments in the mass production area even though some special use production facilities had to be acquired. At the present time, consumer needs are taking on more diversity so that product lines must also become diverse, and the volume of any single product tends to become smaller. The production facilities of a plant must be able to fulfill these demands and still retain their economic aspects.

The FMS (flexible production system) is a new production system that was developed to cope with these needs of the industrial world. It is the assembly robot which is the mainstay of this FMS. For example, when different products are to be turned out on a given production line, the FMS plays a representative role. Furthermore, when FMS completes production of a given product, the same facility can be converted for production of another product and thereby raise the efficiency in facility investment recovery. It may be said that the FMS is a production system which has the flexibility to exploit robotics in place of the special use automated machines of the past.

As discussed above, the demand for assembly robots has increased sharply recently. This is an indication that robot production has increased greatly over the past several years (see Table 1 [2]).

Table 1. Number of Industrial Robots Produced by Year (Unit: 1,000 sets)

(1) 年	1974	1975	1976	1977	1978	1979	1980
(2) 生産台数	4.2	4.4	7.2	8.6	10.1	14.5	19.9

Key:
1. Year
2. Number produced

Fujitsu is also a manufacturer of semiconductors and electronic parts. Needs are also diversifying in these areas and product diversification is undergoing sharp advances. Semiconductor production involves much fine work which relies on human hands with their finely distributed nerves, and the characteristic of such work is the large psychological load on the worker. At the same time, the presence of man is associated with the generation of dust, which presents a major problem in quality control. A shift has to be made from production by human hands to automated production using machines, and an unmanned production plan has to be the eventual goal in order to resolve this situation. It is the precision assembly robot which is the backbone of such a system. Assembly of semiconductors require micron order precision. At the same time, with the higher performance of semiconductor products, even greater precision is in order in the trend that is unfolding. Higher precision will also be required of the assembly product.

The prototype robot PROTO was developed in 1978 with the purpose of responding to the need for an assembly robot of the type discussed above (see Figure 1).

The PROTO is a robot with 4 degrees of freedom operating on cylindrical coordinates, and a positional resolution of 1 μm. In addition to this robot of precision operating capability, the FAROT-S4 with a selective compliance mechanism to perform general assembly was also developed. Fujitsu developed robots capable of performing fine work with great precision. While these robots were suited to the assembly of fine parts, their operational area was comparatively small, and the applicable operations were rather limited. This was why a robot with more expanded applicable area of assembly operations was developed and this is the FAROT-M6 which is an assembly robot for precision assembly. We plan to use the assembly technology of this robot for applied technology to other areas.

3. FAROT-M6 Robot

This is a teaching playback type robot. Teaching involved a man teaching the robot just how operate. The playback refers to the robot responding to what was taught and repeating the same operations. In other words, the FAROT-M-6 repeatedly performs the operation it was taught by man. Teaching involved actual operation of the robot so that it records all essential positional data in its memory facility. The robot then can use this recorded data and repeat the operations it had been taught. Since a man must teach the robot every detail of the operation, the simplification of the teaching step is the factor responsible for the ease in use of a robot. Operations according to a robot language have been adopted with the FAROT-M6 to simplify this robot teaching.

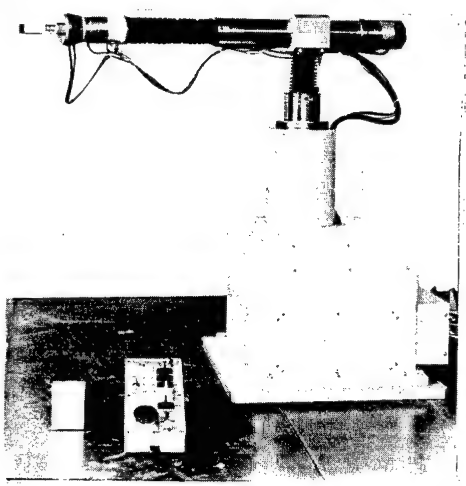

Figure 1. PROTO Robot

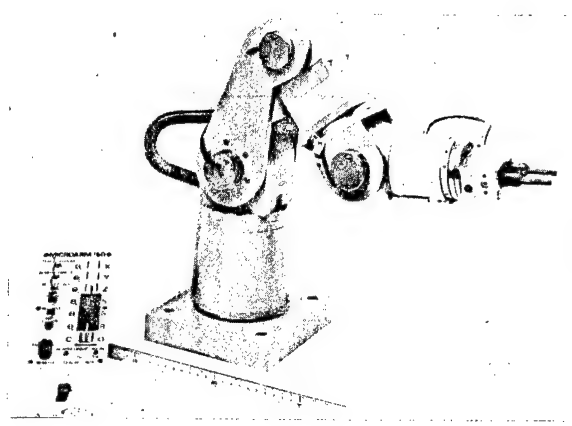

Figure 2. MICROARM-150 Robot

The FAROT-M6 is comprised of the robot main body, control system, and the accompanying software.

3.1 Robot Main Body

This robot is a multijointed affair with 6 degrees of freedom combining rotational and bending capabilities, and its fingertip can be operated in 10 μm steps. The robot main body is shown in Figure 3 and its arm construction in

Figure 4. Each arm is operated by a DC servo motor with speed reduction attachment and an optical rotary encoder. The length of each arm is as shown in Figure 3, and there is a distance of 645 mm from the center of the base to the center of where the hand is attached when the arm is fully extended, and this is an arm length roughly similar to that of man. The working area of this robot is illustrated in Figure 5. Its multijointed construction greatly expands its field of applications.

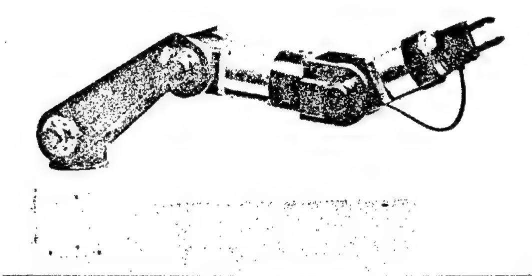

Figure 3. FAROT-M6 Robot

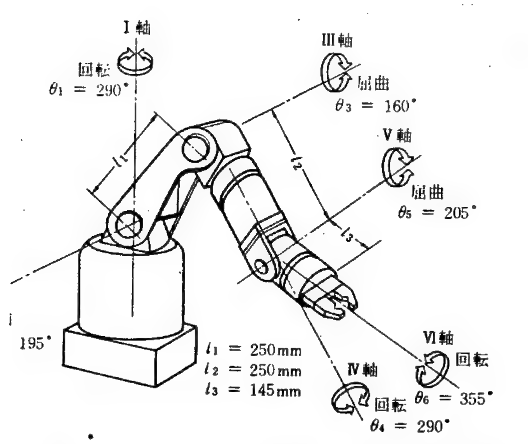

Figure 4. Links and Joints of FAROT-M6 Arms

Key:

1. Axis I
2. Rotation
3. Axis III
4. Bending
5. Axis V
6. Axis II
7. Axis IV
8. Axis VI

3.2 Specifications

The principal specifications are given in Table 1 and the detailed specifications for each arm are listed in Table 3.

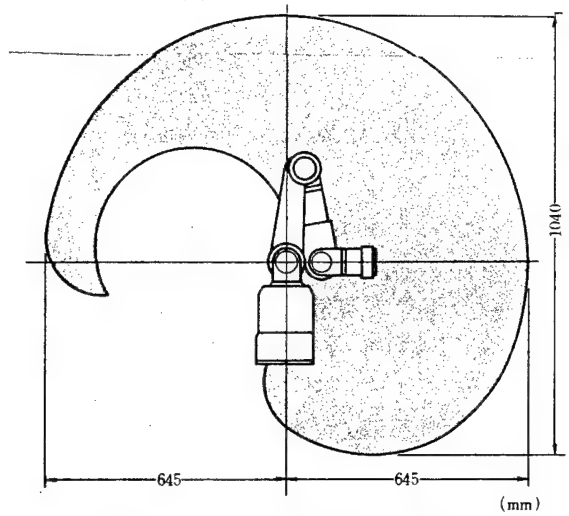

Figure 5. Working Area

Table 2. Principal Specifications

Robot main body section	Shape	Multiple joint type
	Degrees of freedom	6
	Transporting weight	2 kg
	Maximum moving speed	3.3 m/s
	Weight	20 kg
Control section	Control method	High-speed servo control with DC motor
	Number of control axes	Each axis individually, six axes simultaneously
	External connections	RS232C one channel 72 bit digital I/O

(1) 軸	(2) 動作範囲	(3) 最小移動設定値
I (θ1)	290度	0.55秒
II (θ2)	195度 (4)	2.88秒 (5)
III (θ3)	160度	2.88秒
IV (θ4)	290度	2.88秒
V (θ5)	205度	2.88秒
VI (θ6)	355度	2.88秒

Table 3. Detailed Specifications for Arm

Key:
1. Axis
2. Operating range
3. Minimum movable set value
4. -- degrees
5. -- second

3.3 Control System

The system makeup is shown in figure 6. This system is comprised of a 16 bit microcomputer and sole use processor, 128 K bit RAM, floppy disk facility, servo control device for each display device and arm, and the various interfaces. PASCAL is the program language used, and the programming, teaching, and data accumulation can be handled by a conversational mode using the display device.

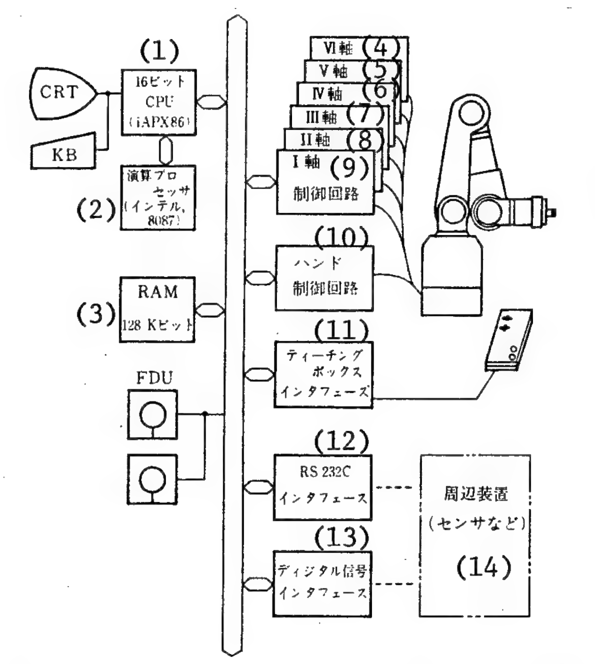

Figure 6. Configuration of Control System

Key:
1. 16 bit CPU
2. Computing processor (Intel 8087)
3. 128 K bit RAM
4. Axis VI
5. Axis V
6. Axis IV
7. Axis III
8. Axis II
9. Axis I control circuit
10. Hand control circuit
11. Teaching box interface
12. RS 232 C interface
13. Digital signal interface
14. Peripheral devices (such as sensors)

3.4 Software

As shown in Figure 7, the robot software system is comprised of two types of control modules centered on the operating system. The software is provided with the following capabilities in order to facilitate robot use.

1) Control using robot language

i) Synchronization with external equipment and handling of sensor signals are important in an assembly robot. These can be narrated in simple form.

ii) There are many occasions for repeats of the same operations in assembly work, This is why operation of the robot can be realized through simple commands.

iii) There is an interpreter capability to enable robot operation during programming.

2) Control through teaching

Data insertion, deletion, or alteration type editing through teaching is facilitated.

3.5 Features

FAROT-M6 is provided with the following features in order to conduct precise assembly operations.

1) Unit mode

This is a mode to operate just the designated arm and it is an effective mode when the robot is involved in a major movement.

2) Intersecting coordinate mode

This is a mode that facilitates robot movement because the robot position, operating space, and parts location are represented by an intersecting coordinate system. For example, this is an operating mode in which a man can readily instruct the robot to perform such functions as positioning parts for an assembly operation or inserting parts into holes in a XYZ intersecting planar system.

3) Hand coordinate mode

This is a mode to be used when parts held in different hands or when some arbitrary point in space is established at which the attitude of the hand and the part are moved in parallel manner. An example is the insertion of a part into a hole in an inclined plane, and this is a mode that can be advantageously applied to change the attitude of a part being grasped while it is being moved.

By teaching through the appropriate combinations of these three operating modes, the load on the teaching process on the part of the operator is reduced.

3.5.2 Track Control

The position of the robot is sampled at fixed time interval ΔT in the FAROT-M6 in order to obtain a smooth and accurate track, and the velocity vector necessary for the robot to get to the next time increment (ΔT) is constructed to control this track in the method that has been adopted. Assume that the robot moves in a straight line from point A to point B in space. Also assume that the coordinates of points A and B are represented by XYZ intersecting coordinates. Representing the speed of transition from point A to point B vy v, the straight line which ties together A and B (equivalent to the direction of transition) can be represented by an appropriate formula. We now explain this movement in the X axis direction. We calculate the robot position X_k at some given sample time t_k from the measured value of the arm rotational angle Θ_n ($n = 1, 2, \ldots 6$). When this movement is at velocity v, the point X_{k+1} is calculated, and the velocity vector X_k is determined. The direction of movement at this time can be represented on the XYZ intersecting coordinates, but the actual situation requires that the velocity vector should be given as the rotational angular velocity of each arm, and a conversion of the X coordinate system to the rotational coordinate system (Θ_n coordinate system) is necessary. At the same time, a conversion from the rotational coordinate system to the X coordinate system is required at every sampling when the initial robot position is being determined. This requires a special computational processor. Since the velocity vector is required for every point of passage of the robot in this mode, smooth operations free of start/stop stages are possible compared to the track control method requiring passage site designations. In addition, even when track errors are created through changes in friction or load, there is the advantage of automatic corrections to obtain accurate tracks through the velocity vector. This pattern is illustrated in Figure 8.

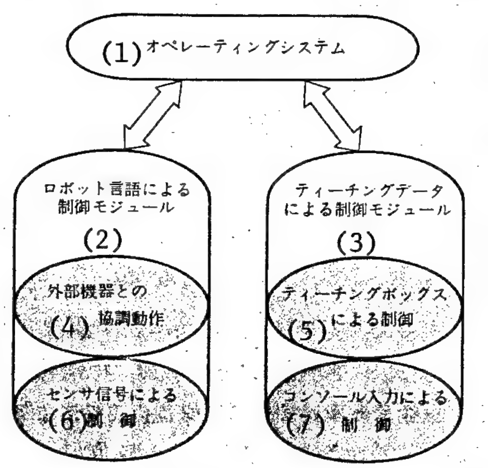

Figure 7. Software System

Key:

1. Operating system
2. Control module using robot language
3. Control module using teaching data
4. Coordinated operation with external equipment
5. Control through teaching box
6. Control through sensor signals
7. Control through console imput

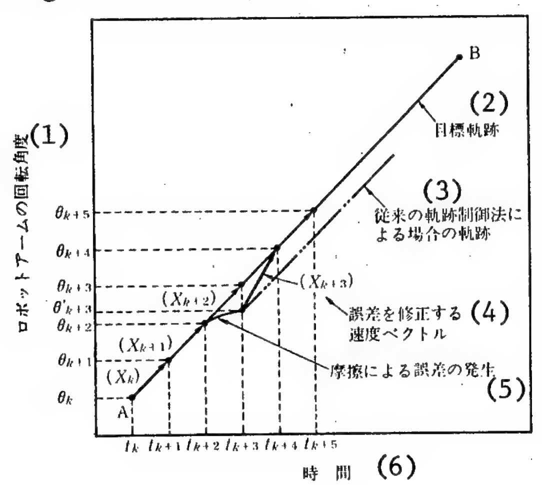

Figure 8. Locus Control of Robot Arm

Key:

1. Operational angle of robot arm
2. Targeted track
3. Track by track control method of the past
4. Velocity vector to correct error
5. Generation of error by friction
6. Time

3.5.3 Servo Control

A precision robot must have the movement resolution capability of correctly responding to fine positional commands necessary to assembly. This is materialized in the FAROT-M6 by a servo control utilizing multifunctional control theory. This servo system has two functional sections as illustrated in Figure 9.

1) Reference function generator

The function generator is the section which generates the targeted values for the position X_R and acceleration a_R which the robot follows to get to the next position. We represent the command position from the control device by X_C, the command velocity by V_C, and the initial acceleration by V_a. When the robot is between $V_C > V_a$, it is in an accelerating mode with switch S_1, and the targeted position values are given continuously. Constant speed travel is attained at

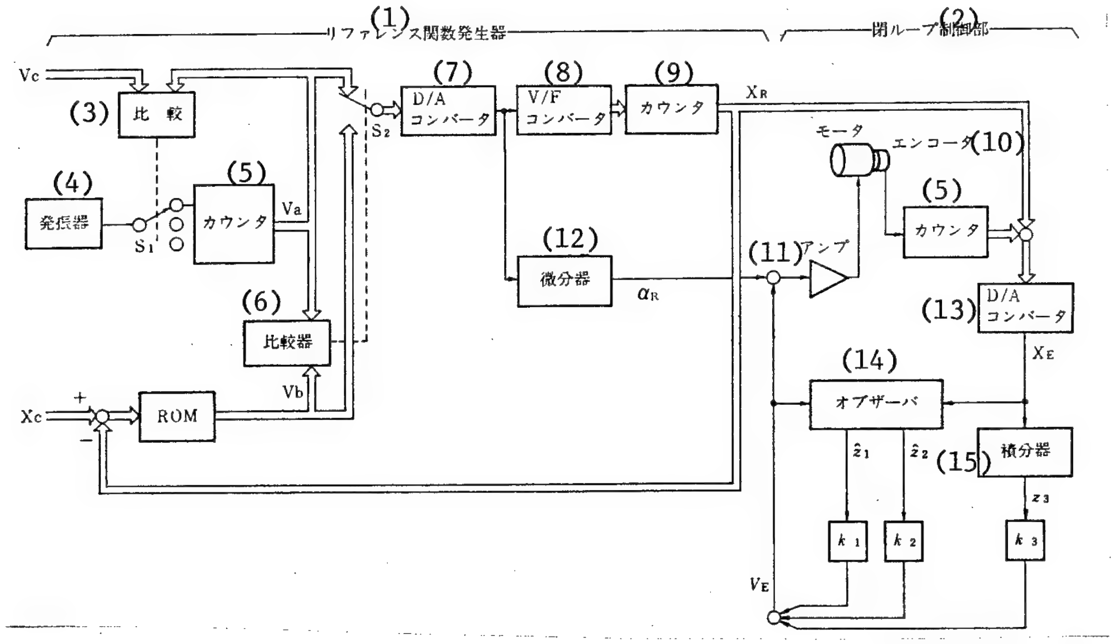

Figure 9. Configuration of Servo System

Key:

1. Reference function generator
2. Closed loop control section
3. Comparison
4. Oscillator
5. Counter
6. Comparator
7. D/A converter
8. V/F converter
9. Motor
10. Encoder
11. Amp
12. Differentiator
13. D/A converter
14. Observer
15. Integrator

$V_C = V_a$, and as the robot nears command site X_C, there is a change to a decelerating mode by the action of switch S_2. When in a decelerating mode, a velocity pattern is commanded as the targeted value according to the difference between the command position and the present position. This method makes possible stopping the robot at the command position with no vibrations. By the use of the function generator, it is possible to freely construct any desired velocity profile, and changes in velocity when the robot is moving are also possible. The track control discussed in the preceding paragraph utilizes this control.

2) Closed loop control section

The control section accurately responds to changes in friction and load associated with the robot and enables smooth functioning. The feature of this control section is the three variable feedbacks of position deviation signal $\hat{z}_1$, velocity deviation signal $\hat{z}_2$, and cumulative error z_3 (this is called multivariable control because three variables are fed back simultaneously). These

three vairables are used to control the current to the DC motor which operates the robot arm. Representing the voltage applied to the motor by V_E

$$V_E = k_1\hat{z}_1 + k_2\hat{z}_2 + k_3z_3$$

These gains k_1, k_2 and k_3 are selected to minimize the cumulative error and are determined by optimum regulator theory to optimize the current following through the motor. This evaluation function is

$$J=\int_0^\infty (mz_3^2+V_E^2)\,dt,$$

(m: weighting coefficient)

and the values of k_1, k_2, and k_3 which minimize J are determined to obtain a control system of high stability. This method enables high precision in position determination by integration compensation and fast response to be realized simultaneously.

4. Future Developments

When sole use fabrication machinery or an assembly machine are made to operate automatically, the present robots may be said to be automated machines which faithfully repeat what they have been taught. A robot has the felxibility to alter its working routine according to the commands of its operators, but it cannot respond to any other activity other than the given commands. Even when there are some slight changes in the work contents, teaching is still necessary, and the adequacy of the teaching process is evidenced in the actual operation. As a result, various sensory functions need to be incorporated into the robot to make the robot operate according to this sensory information in order to utilize the robot in assembly operations in a stable manner. A robot with such capabilities is called an intelligent robot. The makeup of an intelligent robot is shown in Figure 10.

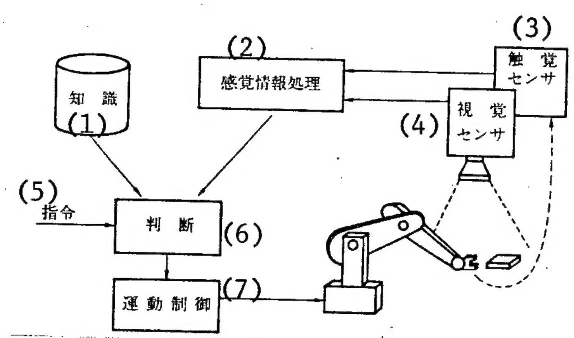

Figure 10. Configuration of Intelligent Robot

Key:
1. Information
2. Sensory infromation treatment
3. Touch sensor
4. Visual sensor
5. Command
6. Judgment
7. Operation control

An intelligent robot has the capabilities to view the executional situation of the work at hand and to view the environment, and it can adapt the work contents in accordance with changes in the external situation using these capabilities. That is to say, it is a robot with the capability of intelligent judgment, and it has sensibility sensors and sensible information processing capability. The sensibility sensors include a visual sensor to recognize objects and gauge distances as well as touch sensors which measure forces involved when objects are contacted. As microelectronics progress still further, there will be the possibility of developing robots with learning capability and reasoning capability, and the creation of an automated production system with a robot group may no longer be a dream.

On the other hand, when seen from the robot's utilization end, the coupling of CAD/CAM (computer aided design/computer aided manufacturing) with robots is expected to result in still further automation of production facilities. A technology to simulate robot activities becomes important in such a system. At the present time, a robot has to be actually operated or the actual functions of the robot are not understood in the deficiency that is faced. On the other hand, it should become possible to unravel a robot's operation by use of a simulator and it will become possible for anybody to use a robot in a simple manner. At the same time, the development of a robot language suitable to expand functioning of robots is necessary in order to make possible the ready use of robots.

Fujitsu is promoting research to advance development of the intelligent robot (see Figure 11). This intelligent robot system combines visual awareness and robot operation to allow shape recognition and positional measurement of an object and thereby to single out an object which has been pointed out by the user. When this system is used, the sensibility sensors include a television camera, and the information picked up by this camera is processed to remove noisy images, extract contours, measures features, make positional measurements, and match patterns with objects whose features have been recorded beforehand.

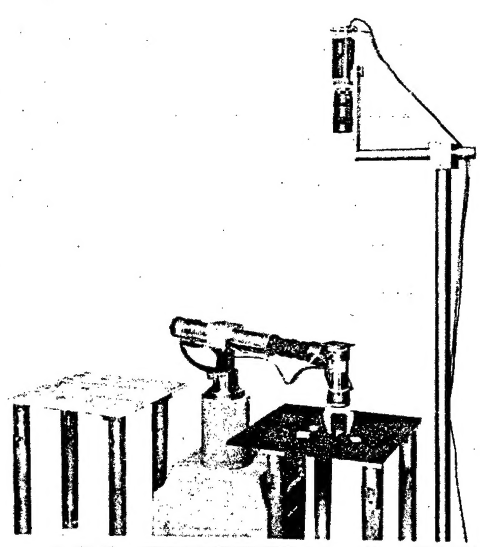

Figure 11. Example of Intelligent Robot

The touch sensor is an important sensor for the assembly robot. The touch sensor measures the force sensations when parts are being assembled, and it uses this information to fit together parts without incurring damage and even to align the parts. This is equivalent to the functions of human fingers and wrists. Some new concepts are being introduced to promote development even in the area of touch sensors.

At the present time, the assembly robot is believed to operate as a combination of awareness over a wide range through the visual sensor and the contact awareness of the touch sensor. When it is considered that stereo recognition of objects with a visual sensor technologically involves a number of difficulties at the present time, the touch sensor assumes greater importance.

The robots to date were developed by combinations of present technology. On the other hand, the development of the high performance robots of the future will require the development of special technology solely for robots. Some of the technological contents for future development are listed in Table 4.

Table 4. Technological Items Requiring Development

(1) 技術項目	(2) 例	(3) 開発項目
(4) 駆動源	モ (5) タ	小形化，軽量化，高能率 新形アクチュエータ (6)
(7) ロボット構造	ア (8) ム	多自由度化，移動機構 (9)
(10) 制御	—	高精度化，分散制御化 (11) ロボット用プロセッサの開発
(12) ソフトウェア	—	ロボット言語 ロボットシステムのシミュレーション (13)
(14) センサ	視覚 (15) 触覚	小形化，軽量化 高分解能化 対環境性の向上 (16) 新センサの開発
(17) システム化技術	—	階層構造化，協調作業 高速画像処理技術 高信頼化 (18)

Key:

1. Technological item
2. Example
3. Development item
4. Driving source
5. Motor
6. Miniaturization, lightness, high efficiency new type actuator
7. Robot construction
8. Arm
9. Multiple degrees of freedom, motile mechanism
10. Control
11. Development of high precision and dispersed control processor for robot use
12. Software
13. Robot language, robot system simulation
14. Sensor
15. Visual, touch

16. Development of miniaturized and light weight new type sensors with high resolution and improved environmental awareness.
17. Systematizing technology
18. Layered construction, coordinated operation, high speed graphic treatment technology, high reliability

As discussed above, robots are representative examples of the coupling of machines and electronic technology, and it is a computer which performs work. Robot development from here on should lay emphasis on the incorporation of intelligence. Fujitsu is activating the systematized technology developed with computers to date and expects to develop individual robots (as is to be expected) as well as to promote coordinated work by several robots and develop robotic systems. It also hopes to promote development of highly intelligent robots.

5. Summary

The FAROT-M6 was developed as an assembly robot was introduced. We have just started to utilize assembly robots, and we hope to look at future actual operating records to evaluate this item as a production facility. Based on the results of operating tests, additional functions and improvements will be introduced by which course we hope to develop an easy to use assembly robot.

From here on the industrial robot headed by the assembly robot is expected to be used not only in manufacturing but also new areas in construction, agriculture, forestry, and fishing. In addition, the day is not far off when they will be used in business and service areas as well. Robots should not be considered as merely labor saving devices but also as a readily usable and friendly tool for the creation of an abundant society.

BIBLIOGRAPHY

1. Hattori: Research or Practical Use of Assembly Robots, 1980 Spring Symposium of the Precision Equipment Society, pp 21 f.

2. Japan Industrial Robot Industry, Inc. Statistics, (1982).

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CSO: 4306/286

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